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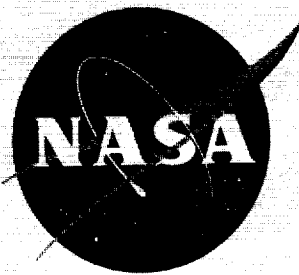
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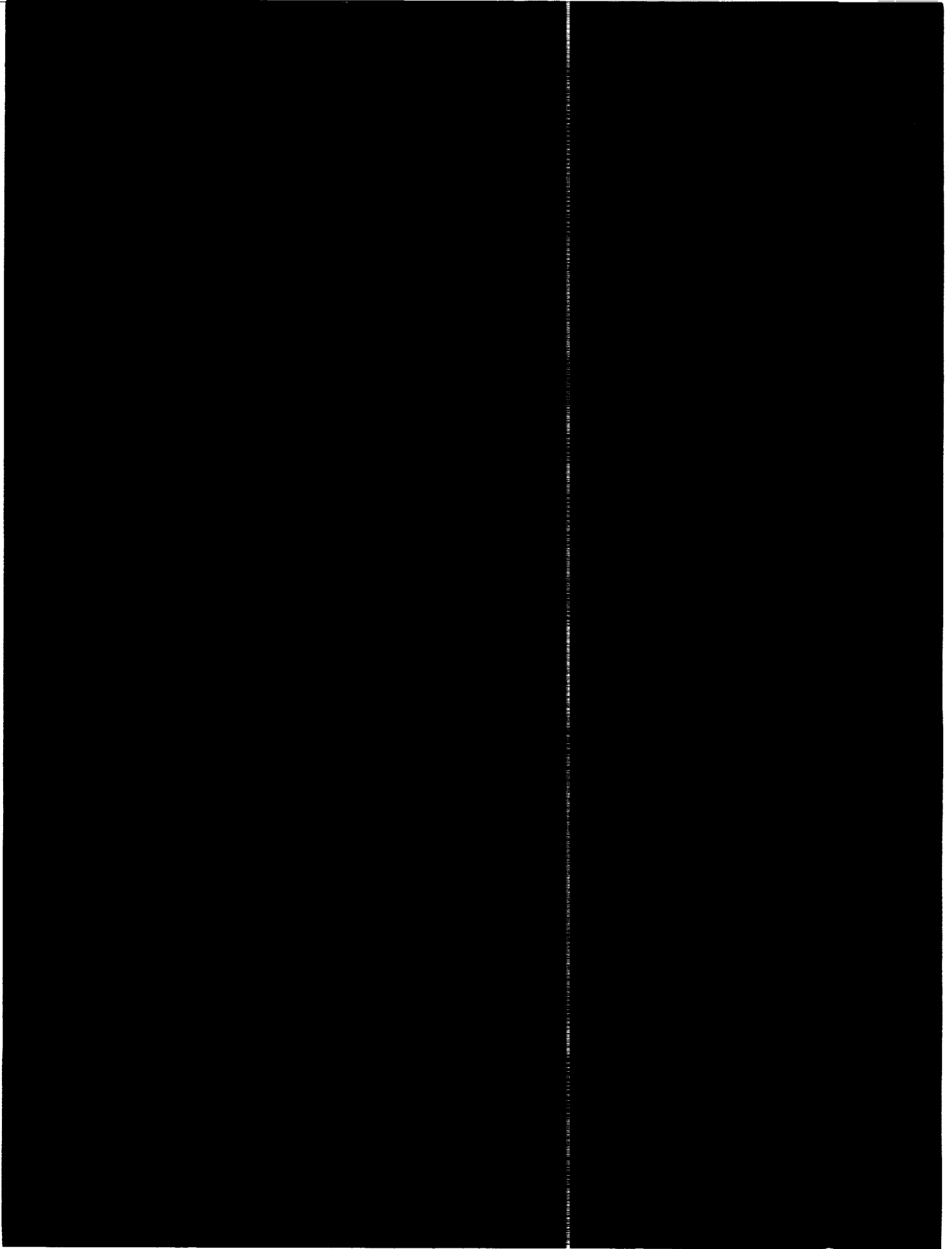# TECHNICAL TRANSLATION
F-7

SOME RESULTS OF THE MEASUREMENT

OF THE SPECTRUM MASS OF POSITIVE IONS BY THE

3RD ARTIFICIAL EARTH SATELLITE

By V. G. Istomin

Translated from the Russian.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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SOME RESULTS OF THE MEASUREMENT

OF THE SPECTRUM MASS OF POSITIVE IONS BY THE

3RD ARTIFICIAL EARTH SATELLITE[*]

By V. G. Istomin

The radio frequency mass-spectrometer installed in the third satellite registered positive ions with mass values of 32, 30, 28, 18, 16, and 14 which were identified as single charged ions of molecular oxygen, nitrogen oxide, molecular nitrogen, atomic oxygen, and atomic nitrogen, respectively. The data obtained ranged from altitudes of 225 to 980 kilometers and latitudinal intervals of 27° to 65° north latitude. Certain patterns in the changing composition of the ionosphere with altitude and geographic latitude have been discovered.

1.- INTRODUCTION

A 7-5 cycle version of the Bennett type radio frequency mass-spectrometer was used in the third satellite for investigating the mass spectrum of the positive ions of the ionosphere. The design of the instrument, its basic parameters, and measuring methods are described in reference 1.

In accordance with the program of the instruments' operations in the satellite and the available power supply, the mass-spectrometer functioned from May 15th through May 25th. A large volume of material - about 15,000 mass spectra at altitudes ranging from 225 to 980 kilometers - was received during that time. The measurements were made only in the northern hemisphere at intervals of latitude from 27° to 65° north latitude. Since the altitude and geographic latitude of the satellite in its orbital flight are in a definite way interrelated, and the time changes in this relation in the case of the third satellite, due to orbital regression, were sufficiently slow, the data on the ionosphere composition obtained in all spirals represent approximately the same complex altitude-latitude cross sections of the atmosphere. Figure 1 shows the orbit of the third satellite in altitude-geographic latitude coordinates for approximately the first 10 days of its existence. It

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[*]Translated from the Russian.

may be seen that any value of the geographic latitude within the range of 65° corresponds to only two values of the satellite's flight altitude and, conversely, any value of the flight altitude corresponds to only two latitude values. This situation complicates the interpretation of the results obtained, and makes it difficult to determine the strictly altitudinal and strictly latitudinal relations of the atmosphere parameters under investigation.

It should be pointed out, in addition to the abovesaid, that all of the material received refers to daytime; that is, what was obtained were the spectra of the atmosphere ions illuminated by the sun. Most of the data were obtained during the morning hours, Moscow time, between 7:00 and 11:00 a.m. The local time will naturally be different, depending on the geographic longitude of the particular trajectory point of the satellite.

2.- THE BASIC CHARACTERISTICS OF THE OBTAINED SPECTRA

Characteristic of the mass spectra of the ions obtained by the third satellite, in addition to the basic (true) mass peaks, are also the so-called harmonic (false) peaks which make the deciphering of the data difficult. The harmonic peaks are present because the effective retarding potential of the mass-spectrometer was found to be greatly lowered for two reasons. Due to the fact that the mass-spectrometer is located on a moving object, all the atmospheric ions possess, in addition to the thermal speeds, a directional (regulated) speed equal to that of the satellite, in relation to the instrument. Because of this regulated speed $v = 8 \times 10^5$ cm/sec, an ion with a mass number M and a charge $q = 4.8 \times 10^{-10}$ C G S E will possess a definite energy equivalent to a certain amount of accelerating tension,

$$\Delta V\sigma = 300 \frac{Mm_0}{-2q} v^2 \text{ volts} \qquad (1)$$

where $m_0 = 1.67 \times 10^{-24}$, and q is the value equal to 1/16 of the atomic weight of oxygen. In the case of ions with a mass number 16, the speed 8×10^5 cm/sec is equivalent to an energy of 5.35 electron-volts, and in the case of ions with a mass number 30 the equivalence is 10 electron-volts. In view of this, the retarding potential of the instrument with reference to equal-mass ions is found to be lowered by various values which are numerically equal to the ion energies expressed in ev (electron-volts). Besides, as an analysis of the obtained spectra shows, the satellite had a negative potential of several volts, which was

also conducive to an additional reduction of the effective retarding potential by a value which is the same for all atmospheric ions.

As a result of the reduction of the effective retarding potential brought about by these two causes, the sensitivity of the mass-spectrometer was found to be several times higher, more in connection with the heavy ions than with the light ones, and the mass resolution was accordingly reduced approximately by one-half in comparison with what it was when the instrument was adjusted in the laboratory.

The instrument had been adjusted to the solution value $R = \frac{M}{\Delta M} \approx 20$ in the sphere of mass numbers 20. Here, as usual, M represents the mass number of the peaks and ΔM its width at the base expressed in atomic mass units. In the obtained spectra of atmospheric ions the peak base resolution in the field of mass numbers 16-14 is equal to 7 + 10. That means that in the given experiment the mass peaks in the field of light $(M \approx 16)$ masses were fully resolved if their mass numbers differed by approximately 2 or more atomic mass units. In the field of heavy masses $(M \approx 30)$, the peaks whose mass number differed by 2 atomic units were not fully resolved. The aforesaid should be borne in mind when the experiment results are reviewed.

The dynamic range of the instrument was found to be considerably wider with respect to high intensities due to the availability of harmonic peaks in the spectra. As the light harmonic level of mass 16 was on the average equal to 0.1 of the basic peak amplitude, when peak 16 was intensive enough for the amplifier's low-sensitive yield to become saturated (the current exceeded 10^{-8} amperes), its value could be estimated by the value of the light harmonic peak.

The mass numbers of all the peaks in the spectra, as had been expected (ref. 2), were found to have moved on the instrument's mass scale toward the light masses under the influence of the satellite's speed and its negative charge. We repeat that in the radio frequency mass-spectrometer in use the mass scanning is realized by a change of the negative accelerating voltage according to the sawtooth law. In laboratory conditions the mass number of the peak is determined by the following formula:

$$M = \frac{V}{k} \qquad (2)$$

where M is the mass number of the peak in atomic mass units, V is the voltage value of the scanning in volts at the time the peak occurs, and k is the instrument's constant, which is equal to 7.2 v/a.m.u. (atomic mass units).

When the instrument is used on the satellite, the negative voltage value of scanning V will be increased by the value ΔVv, which is numerically equal to the electron-volt value of the corresponding ion moving at a speed of 8×10^5 cm/sec, as well as by the satellite's negative potential value ζ. Formula (2) should in this case be rewritten as follows:

$$M = \frac{I}{k}(V + \Delta Vv + \Delta V\zeta) = M_{dec} + \Delta Mv + \Delta M\zeta \qquad (3)$$

Here M_{dec} represents the mass number of the peak determined by deciphering the entry of the scanning voltage at the time it occurred; ΔMv is the correction, taking into account the satellite's speed, and $\Delta M\zeta$ taking into account its charge.

The value ΔVv itself, as can be seen from formula (1), depends on the mass number of the ion, and the formula for determining the mass number of the peak may therefore be recorded as follows:

$$M = \frac{I}{k}\left(\frac{V + \zeta}{I - 300m_0 v^2/2qk}\right) = \frac{M_{dec} + \Delta M\zeta}{I - 300m_0 v^2/2qk} \qquad (4)$$

or definitively, by substituting the numerical values of the magnitudes:

$$M = \frac{I}{k}\left(\frac{V + \zeta}{I - 0.334/k}\right) = \frac{M_{dec} + \Delta M\zeta}{0.954} \qquad (5)$$

As may be seen from formula (5), the shift of the mass peaks under the influence of the speed with regard to the instrument in use should be 0.74 atomic mass units for mass 16 and 1.39 atomic mass units for mass 30.

3.- DECIPHERING THE SPECTRA

The major difficulty in deciphering the mass ion spectra was the separation of the basic (true) mass peaks from the harmonic (false) peaks. The nature of the spectrum registration is shown in figure 2 where copies of four photograms are reproduced. The first and second represent ion spectra in the area of the perigee along the low and high sensitivity channels of the mass-spectrometer amplifier, respectively, and the third and fourth are analogical recordings in the altitude range of about 350 km. The registrations were made on May 23, 1958, at about

9:00 a.m. Moscow time. The first two entries were made when the geo-
graphic latitude of the satellite's flight was 55° north latitude, and
the second two entries when it was 64° north latitude. Conspicuous in
the perigee area of ion spectra is an abundance of peaks and a low
resolution, particularly in the field of large mass numbers.

The separation of the basic and harmonic peaks in the spectra was
made by way of comparing their amplitudes and the nature of their changes
according to the altitude of the satellite's flight and its orientation.
The places of the harmonics in the spectra had been determined beforehand
by laboratory experiments with reference to this particular instrument.
Another criterion that serves to confirm the correctness of the identi-
fication of the basic and harmonic peaks is the fact that the relative
width of the harmonic peaks is smaller than that of the basic peaks.
That had also been established by laboratory experiments.

After the correction was made for the satellite's speed according
to formula (5), the mass numbers of the peaks accepted as the basic
(true) ones differed from the even integral values by some part of an
atomic mass unit. That difference was explained by the negative charge
of the satellite. For example, for May 22 and May 24 (orbits 96 and
122, respectively) the average differences between the parts of the loop
wherein the measurements were made amounted to 0.3 and 0.5 atomic mass
unit, respectively. Taking the value constant of the instrument as
$k = 7.2$ v/a.m.u. (volt/atomic mass units), the satellite's negative
potential will be equal to 2.2 and 3.6 volts.

Predominant in all the spectra, in point of intensity, is the peak
whose mass number was close to 16 after the correction for the satellite's
speed had been made. On this basis, the given peak was identified with
the atomic oxygen peak O^+.

The second most intensive light peak, also present in the spectra
at all altitudes, is the one with a mass number 14. It would be most
natural to identify it with the atomic nitrogen peak N^+. The peaks with
mass numbers 12 and 10.5 were grouped with the light harmonic peaks 16
and 14, respectively.

Adjoining peak 16 in the field of heavy masses is the peak with a
mass number 18 which is very weak but clearly detectable in many spectra.
Its relative intensity has been determined as equal to
$i_{18}/i_{16} = \left(0.2 \begin{array}{c} \pm 0.05 \\ - 0.1 \end{array}\right)$ percent. This peak is not the harmonic of some
basic peak present in the spectrum, and its occurrence can be explained
only by the presence of a corresponding ionized molecule or atom in the
atmosphere. The given ion can be identified either with the ion of
water H_2O^+, or with the ion of another hydrogen compound, NH_4^+. In the

light of such an identification, the presence of an ion with a mass
number 18 should serve as an indirect indication of the presence of
appreciable quantities of neutral or ionized hydrogen in the upper
atmosphere. There is another and more reasonable possibility, however:
The mass 18 peak should apparently be attributed to an isotopic ion
of oxygen with an atomic weight 18 whose relative abundance is 0.2 per-
cent. The problem can be finally resolved by further accurate
measurements.

In addition to the group of light peaks 18, 16, and 14 in the spectra
obtained at different altitudes in the perigee area, there is a fairly
conspicuous group of heavy peaks with mass numbers, 32, 30, and 28 which
were also classified as basic (true) peaks. The most intensive among
them is the peak with a mass number 30 which should be identified with
the ion of the nitrogen oxide peak NO^+. The peaks with mass numbers 32
and 28 should naturally be attributed to the ions of molecular oxygen
O_2^+ and molecular nitrogen N_2^+. Despite the fact that the given three
heavy peaks have not been fully resolved, and the extreme ones, particu-
larly peak 32, frequently combine with the average peak 30, their presence
in the spectra is undoubted and quite evident.

All the other peaks in the spectra, represented in figure 2, should
be classified among the harmonic (false) peaks. Thus the group of three
peaks, the most intensive of which is the one with a mass number 22.5, is
represented as consisting of three light harmonic peaks 32, 30, and 28.
In some spectra it is also possible to discern here the heavy harmonic
of peak 16 with a mass number 22.8. The peaks with mass numbers 40 and
43 are the heavy harmonics of peaks 28 and 30.

All the peaks in the photogram recordings of the mass spectra shown
in figure 2 are marked according to the mentioned identification. The
basic (true) peaks are designated by appropriate chemical symbols, and
the harmonic (false) peaks are indicated by the letter Γ with a partic-
ular index. For example, the light harmonic of atomic oxygen is shown
as ΓO^+, and the heavy harmonic of a nitrogen oxide ion as ΓNO^+.

4.- THE PATTERNS DISCOVERED IN THE CHANGING COMPOSITION OF THE

IONOSPHERE ACCORDING TO ALTITUDE AND GEOGRAPHIC LATITUDE

When reviewing the results cited in this section, one should bear
in mind that all the data apply only to the intensities of the mass peaks
measured in units of current. The peak intensities should naturally be
connected with the relative and absolute concentrations of the appropriate
ions but this connection may be quite complicated, and the question has
not yet been finally elucidated. The difficulty involved in a comparison
of the relative intensities of ionic peaks with a view to obtaining

information regarding the concentration of the appropriate ions is that
it is necessary to take into account the mass discriminant which must
inevitably occur in the described experiment.

The discrimination of ions of various masses will occur, first of
all, in the field of the satellite itself if it has no zero potential
relative to the imperturbable plasma. The presence of a backlash field
created by the first grids of the mass-spectrometer tube will bring
about an additional discrimination of ions. Finally, in the analyzer
itself the ions with various masses will be found in different states,
depending on the initial energy with which they have entered the analyzer.
As was noted in section 2, the initial energy of the ions with mass num-
bers 16 and 30 on the satellite under experimental conditions was approxi-
mately twice as high. In accordance with this, the level of the stopping
potential with respect to these ions will also be different, and the
peak intensity ratio will not equal the concentration ratio of the corre-
sponding ions when they enter the analyzer.*

In line with this, however, it should be borne in mind that the
effect of mass discrimination, whatever the reasons for it, can be great
only in the case of ions whose masses are considerably different from
one another, and small in the case of ions close to each other in point
of mass. In this latter case the ratio of mass peak intensities is close
to the ratio of concentrations of the given ions. For example, the ratio
of the peak intensities of atomic nitrogen and atomic oxygen or molecular
nitrogen and nitrogen oxide should be close to the ratio of their concen-
trations in the ionosphere, whereas the ratio of the peak intensities of
nitrogen oxide and atomic oxygen is possibly considerably different from
their relative concentrations.

Both the absolute and relative intensities of the mass peaks in the
spectra reveal considerable changes with time. Inasmuch as the func-
tioning of the instrument was controlled and remained unchanged all the
time, the changes in the spectra should be attributed to: (a) the
changing orientation of the analyzer's inlet opening relative to the
satellite's flight direction due to the rotation of the latter; (b) the
changing coordinates of the satellite - altitude, geographic latitude
and longitude; and (c) the changing external conditions, the factors
affecting the ionization of the atmosphere.

The first group of changes connected with the satellite's rotation
is made apparent by the revealed periodicity which coincides with the
one established in the other experiments on the third satellite (see
refs. 3 and 4, for example). An examination of sufficiently lengthy

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*The first two factors - discrimination in electric fields - are
conducive to a reduction of the relative intensities of the heavy ions
as compared with the light ones, whereas the last factor operates in an
opposite direction and may compensate for that reduction in some measure
or even produce an inverse effect.

recordings (on the order of tenths of a second) makes it possible to single out the groups of spectra obtained during the most favorable orientation of the analyzer's inlet opening in relation to the flight direction, namely when the angle between the normal to the inlet opening of the mass-spectrometer tube and the satellite's speed vector had a minimum value. A theoretical examination of this question shows that in these conditions the discrimination of ions with various masses should be down to a minimum. This is confirmed also by an analysis of the obtained recordings. The data on the processing of these particular spectra were used primarily in analyzing the composition of the ionosphere and its changes with altitude and geographic coordinates.

As reported earlier (ref. 5), the ion of atomic oxygen O^+ is the everpresent and predominant component of the ionosphere at all the investigated altitudes from 225 to 980 km. This makes it convenient to compare the intensities of all the other mass peaks with the peak intensity of atomic oxygen. The second atomic component of the ionosphere is the nitrogen ion N^+. The ionic current (intensity) of the atomic nitrogen peak changes in relation to atomic oxygen, depending on altitude and geographic latitude, within the range of 1.3 to 8 + 10 percent. The tendency to an increasing content of atomic nitrogen ions, also reported earlier (ref. 5), was confirmed in regard to all the processed spectra. This dependence is graphically represented in figure 3. Overlaid on the horizontal axis is the altitude in kilometers, and on the vertical axis the relative peak intensity of atomic nitrogen as a percentage of the atomic oxygen peak. As pointed out above, this magnitude is close to the concentration ratio of the ions of atomic nitrogen and oxygen. Every data point was obtained as a result of averaging up the measurements of several spectra (from 5 to 20 spectra). The different symbols refer to the different loops between May 18 and May 24, 1958. Attention is called to the fairly large dispersal of the points, amounting to ±3 percent at some altitudes, but it can be seen that that dispersal is not occasioned by errors in the measurements - it reflects the actual changes in the composition of the ionosphere from day to day and from loop to loop. This can be seen in figures 4 and 5, which represent the same dependence of the relative concentration of atomic nitrogen ions on the altitude, but the data of one day are used for every figure. Evidently, the points corresponding to one loop arrange themselves in a small spread on a plane curve while the points obtained from the preceding or following loop are already considerably different from the curve.

In examining figures 3 to 5 it should be borne in mind that, in view of the specific nature of the experiment on the satellite as pointed out above, they do not justify any conclusion on the purely altitudinal changes of the ionosphere composition as the changing altitude of the satellite's flight was paralleled by a change of its geographic latitude. The latitudinal relation of the ionosphere composition can be see particularly distinctly between the altitudes of 225 to 350 km where the latitude change is considerable - from 25° to 65° north latitude.

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Figure 6 shows the data on the concentration ratio of atomic nitrogen and atomic oxygen ions in relation to the particular latitude. The entire altitude range is divided into 5 intervals, and the points applying to the various intervals are designated by appropriate symbols. It is evident that in the altitude ranges of 225 to 250 km and 251 to 350 km the relative concentration of atomic nitrogen ions becomes considerably greater during the transition from the latitude range of 30° to 50° to that of 55° to 65° north latitude. In the altitude range of 351 to 450 km the latitudinal effect cannot be discerned due to the insignificant change of latitude within the mentioned range. As for the still higher altitudes, 451 to 600 km and 601 to 980 km, it is possible to conclude that the relative concentration of atomic nitrogen ions is either no longer related to the latitude or that this relation is considerably weaker but qualitatively the same as in the lower altitudes.

In regard to the spread of the data points of figure 6, reference should be made to what has already been said about the data of figure 3; that is, that the point spread reflects in some measure the ionosphere composition from loop to loop and from day to day. This is confirmed by figures 7 and 8, each of which reflects the latitudinal change of the relative concentration of atomic nitrogen ions for one day. It is evident that all the points with a relatively small spread arrange themselves on a plane curve.

The altitudinal relations of the relative concentrations of molecular ions of oxygen, nitrogen, and nitrogen oxide are similar in nature. At the perigee altitude, the relative intensities of the corresponding ionic peaks are at a maximum, and they diminish fairly rapidly with altitude. The most intensive molecular ion is the nitrogen oxide ion. At an altitude of about 230 km the intensity of the nitrogen oxide ion peak is 25 to 35 percent of the intensity of the atomic oxygen ion peak. The second molecular ion in point of intensity is the oxygen ion O_2^+. Its intensity at the perigee is about 7 to 12 percent of that of atomic oxygen. The peak intensity of molecular nitrogen at the perigee is 1.5 to 3 percent.

The characteristic altitude-relation curves of the relative intensities of the molecular peaks NO^+, O_2^+, and N_2^+ (in relation to O^+), according to the data of a single loop of May 22, 1958 are shown in figures 9 to 11. The characteristic feature of these curves is that they all are clearly divisible into two branches: southern and northern. The data points have been renumbered in the order of increasing geographic latitude: Points 1 and 2 apply to the southern latitudes (before the perigee), and points 3 to 7 apply to the northern latitudes (after the perigee). The latitude increases successively from point 1 to point 6. The last point, 7, corresponds to about the same latitude as point 4.

In figures 9 to 11 the southern branch of the curve runs below the northern branch which points to the relation between the relative concentrations of molecular ions NO^+, O_2^+, and N_2^+ and the geographic latitude: The concentration of ions of nitrogen oxide, molecular oxygen, and molecular nitrogen also increases with increasing latitude in relation to the concentration of atomic oxygen ions.

The molecular oxygen ion peak is traced to a maximum altitude of 400 km, the relative peak intensity O_2^+ ($O^+ \approx 0.1$ percent), and the nitrogen oxide and molecular nitrogen ion peaks to an altitude of 500 km. At altitudes of 400 to 500 km the peak intensities NO^+ and N_2^+ are about the same in relation to O^+ and equal to 0.2 + 0.1 percent. Thus it is only above 500 km that the molecular ions are no longer found, and the ionosphere becomes purely atomic and oxygen-nitrogen, correct to 0.1 percent.

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5.- CONCLUSIONS

1. The daytime measurements of the mass spectra of positive ions at altitudes of 225 to 980 km showed that atomic oxygen ions O^+ are predominant in that sphere. Registered also, in addition to the atomic oxygen ions, were ions with mass numbers 14, atomic nitrogen N^+; 18, oxygen isotope $(O^{18})^+$; 28, molecular nitrogen N_2^+; 30, nitrogen oxide NO^+; and 32, molecular oxygen O_2^+.

2. It was found that the composition of the ionosphere in the investigated sphere changes with the altitude. The relative content (in relation to O^+) of heavy molecular ions O^+, O_2^+, and N_2^+ diminishes with increasing altitude, and the relative content of the light ion N^+ increases with increasing altitude. At altitudes above 400 km the relative content of molecular oxygen ions is less than 10^{-3}, and above 500 km the content of molecular ions of nitrogen and nitrogen oxide is less than 10^{-3}.

3. It was found that the composition of the ionosphere depends on the geographic latitude. The relative content of atomic oxygen ions is considerably larger at altitudes of 225 to 350 km in the transition from the latitude range of 30° + 65° north latitude to the latitude range of 55° + 65° north latitude. The relative content of ions of molecular nitrogen, molecular oxygen, and nitrogen oxide is also considerably larger in the latitude range of 55° + 65° north latitude compared to the latitudes further south.

The author expresses his gratitude to the head of the laboratory
B. A. Mirtov for his constant interest in the work and the discussion
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phering the telemetered recordings and processing the abundant experi-
mental material.

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REFERENCES

1. Istomin, V. G.: Collected Works. Artificial Earth Satellites,
    third edition, 1959.

2. Mirtov, B. A., and Istomin, V. G.: Uspekhi Fizicheskikh Nauk
    (Progress of Physical Sciences), vol. 63, first edition, 227, 1957.

3. Dolginov, S. Sn., Zhuzgov, L. N., and Pushkov, N. V.: Collected
    Works. Artificial Earth Satellites, second edition, 50, 1958.

4. Mikhnevitch, V. V.: Collected Works. Artificial Earth Satellites,
    second edition, 26, 1958.

5. Istomin, V. G.: Collected Works. Artificial Earth Satellites,
    second edition, 32, 1958.
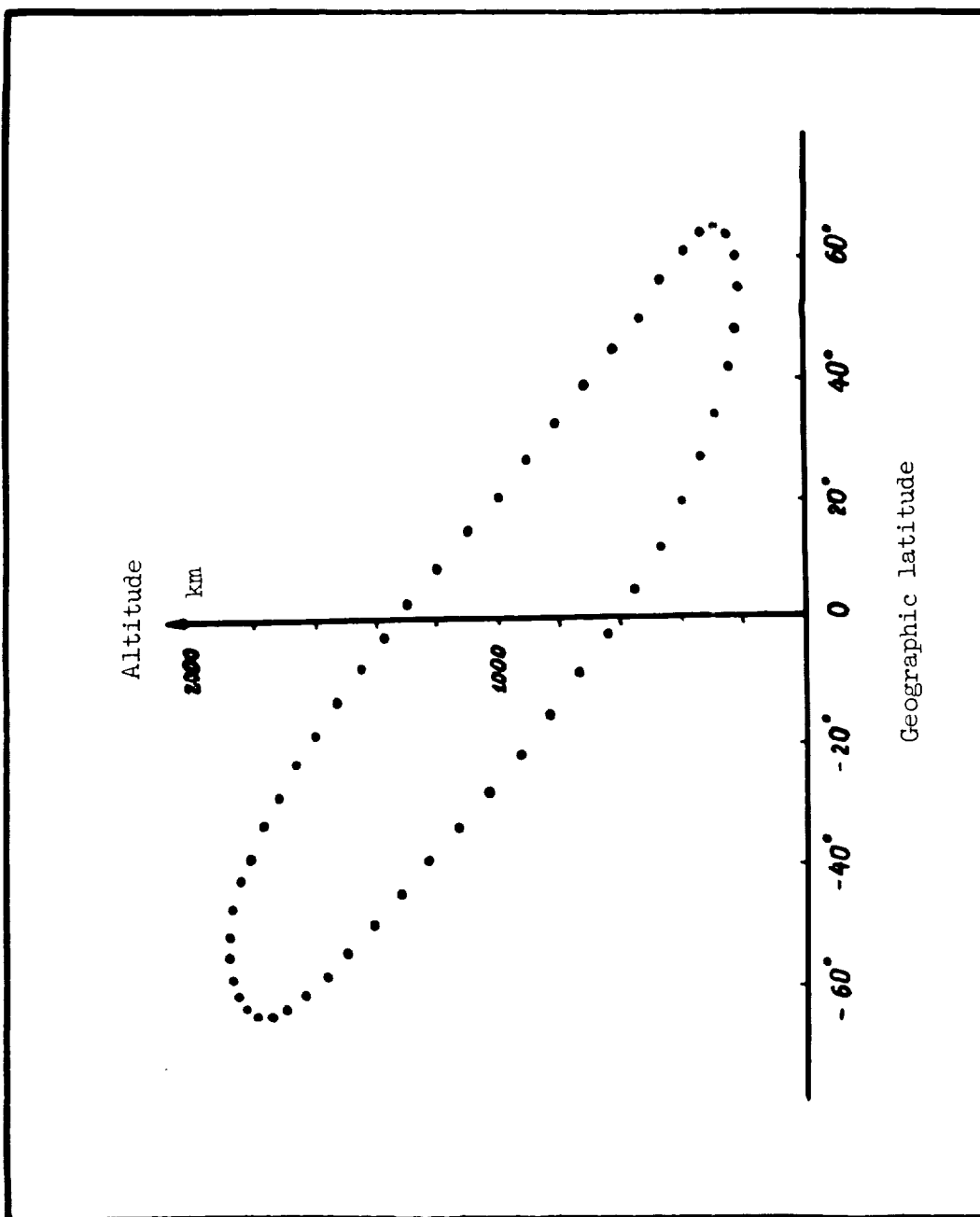
Figure 1.- Orbit of the 3rd satellite in the altitude-geographic latitude coordinates in approximately the first 10 days of its existence.
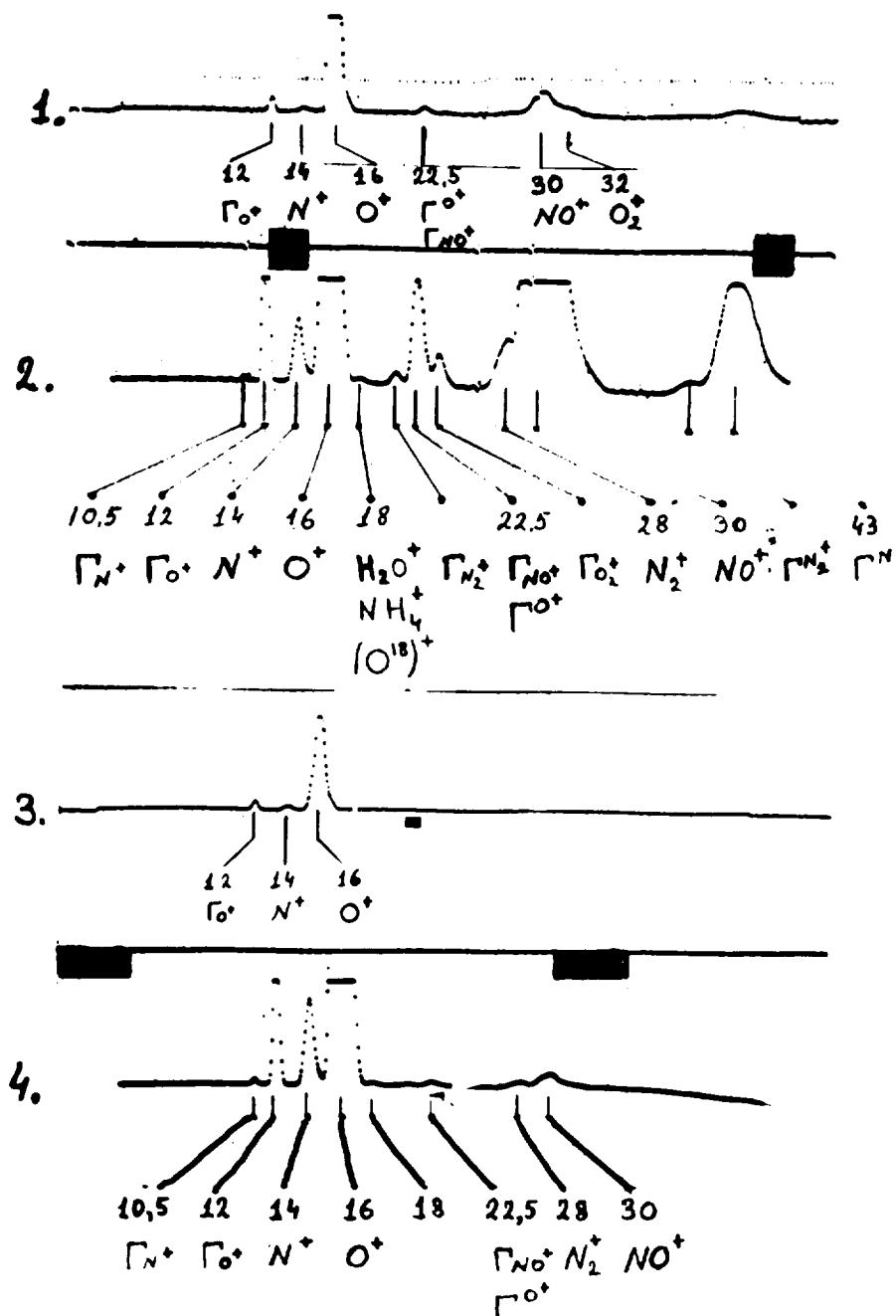
Figure 2.- Registration of mass ion spectra made on May 23, 1958, about 9:00 a.m. Moscow time. 1st and 2nd registrations in the low- and high-sensitivity channels of the mass-spectrometer amplifier; altitude 230 km, latitude 55°. 3rd and 4th registrations, same channels as for 1st and 2nd; altitude 350 km, latitude 64°, north latitudes.
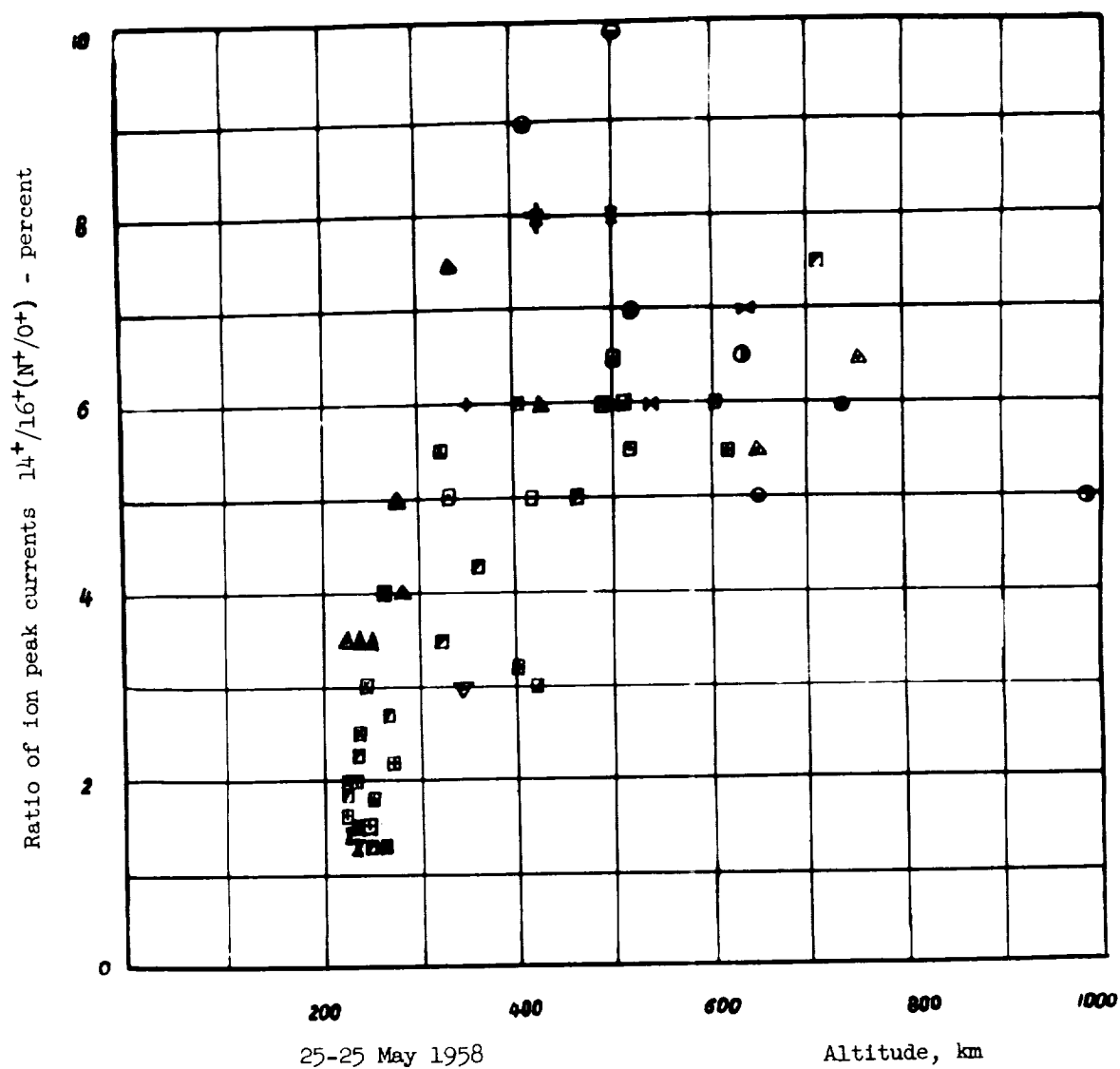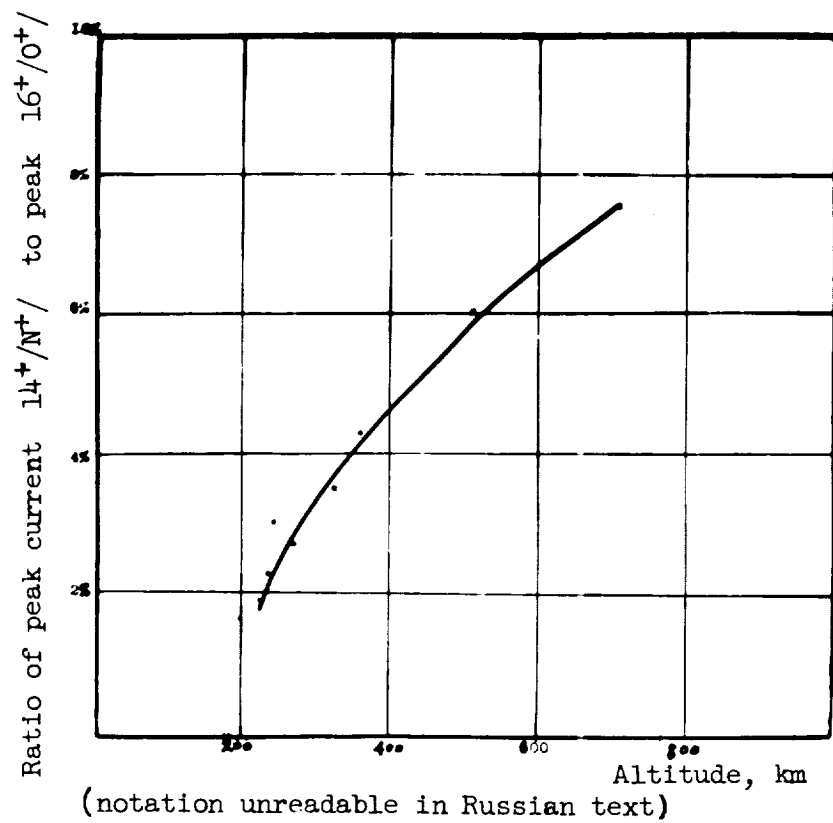
Figure 3.- Changing concentration of atomic nitrogen ions in relation to
atomic oxygen ions according to altitude (based on the data of the
12 loops between May 18 and May 24, 1958).
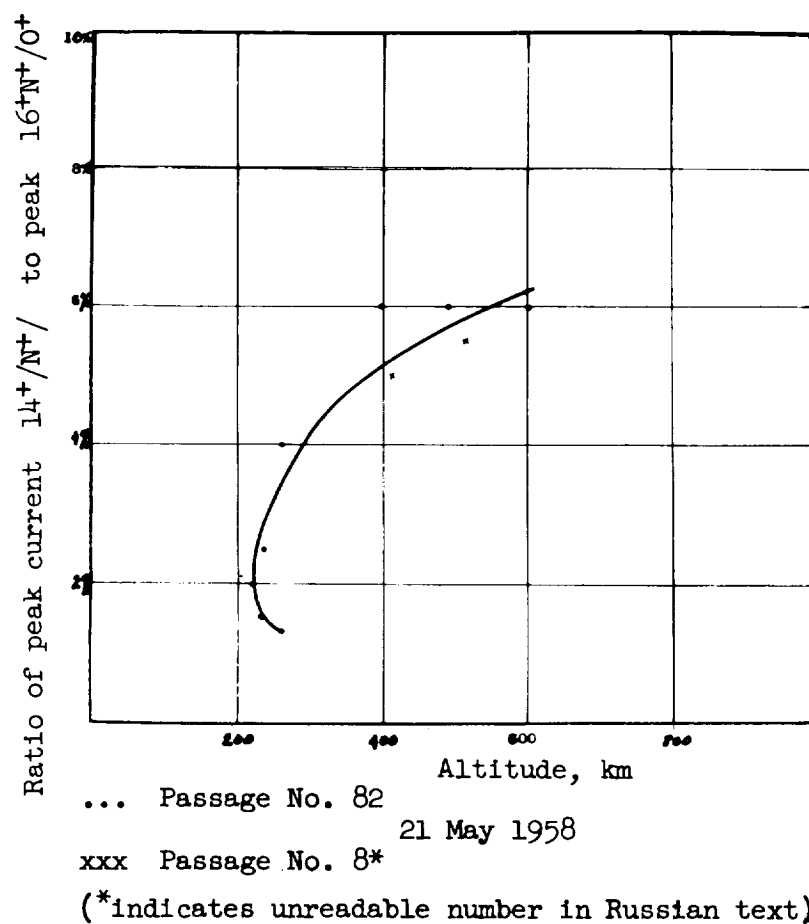
Figure 4.- Changing concentration of atomic nitrogen ions in relation to atomic oxygen ions according to altitude (based on the data of the 2 loops of May 21, 1958).
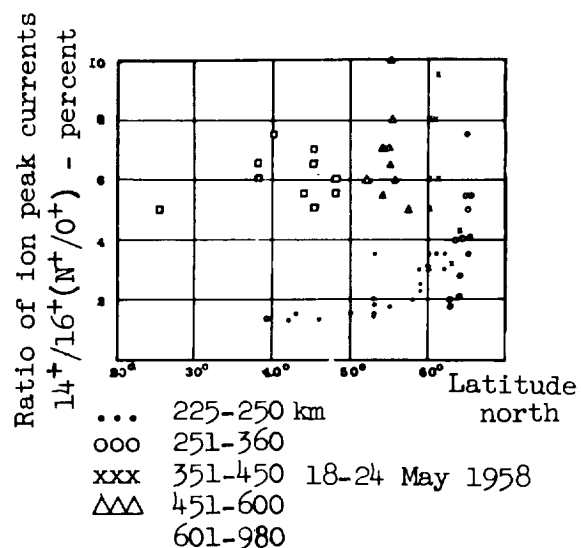
(notation unreadable in Russian text)

Figure 5.- Changing concentration of atomic nitrogen ions in relation to
atomic oxygen ions according to altitude (according to the data of
the 2 loops of May 23, 1958).

... 225-250 km
ooo 251-360
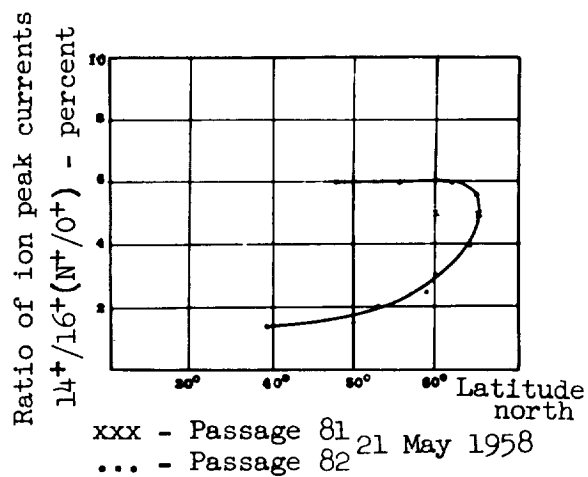**xxx** 351-450   18-24 May 1958
ΔΔΔ 451-600
601-980

Figure 6.- Changing concentration of atomic nitrogen ions in relation to atomic oxygen ions according to geographic latitude (according to the data of the 12 loops between May 18 and May 24, 1958).

xxx - Passage 81
... - Passage 82   21 May 1958

Figure 7.- Changing concentration of atomic nitrogen ions in relation to atomic oxygen ions according to geographic latitude (according to the data of the 2 loops of May 21, 1958).
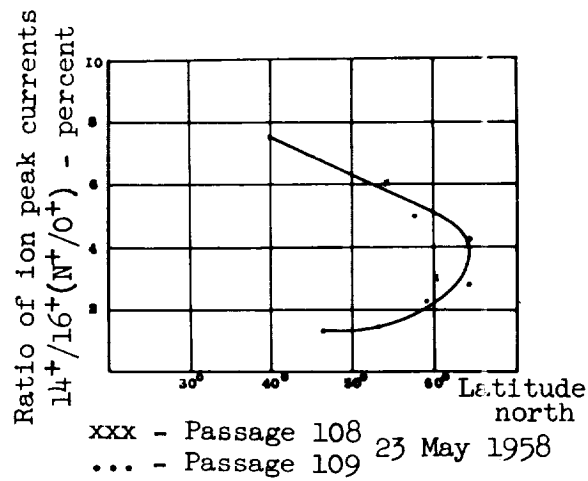
Figure 8.- Changing concentration of atomic nitrogen ions in relation to atomic oxygen ions according to geographic latitude (according to the data of the 2 loops of May 23, 1958).
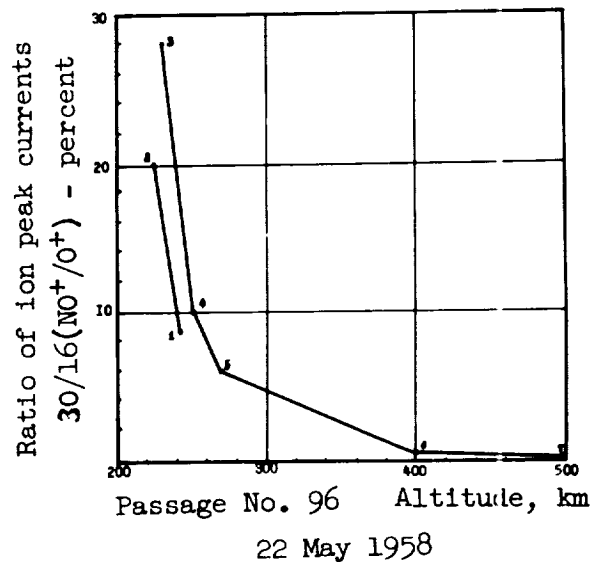

Figure 9.- The changing relative intensity of the ionic peak of nitrogen oxide according to altitude and geographic latitude (according to the data of one loop of May 22, 1958). The points have been renumbered in the order of increasing geographic latitude: 1 and 2 - south latitudes (before the perigee), and 3 to 7 - north latitudes (after the perigee).
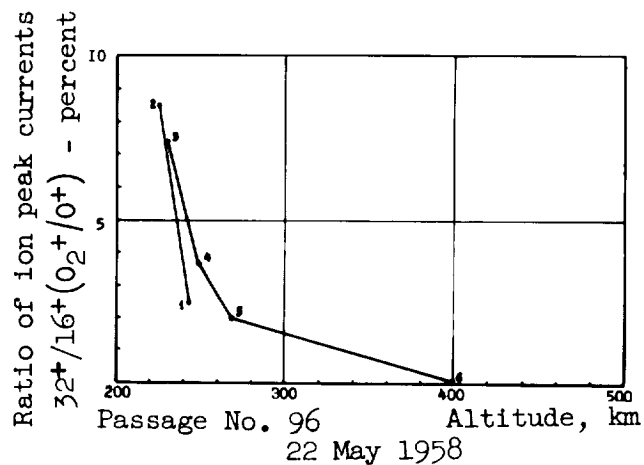
Figure 10.- The changing relative intensity of the ionic peak of molecular oxygen according to altitude and geographic latitude (according to the data of one loop of May 22, 1958). The points are numbered in the same way as in figure 9.
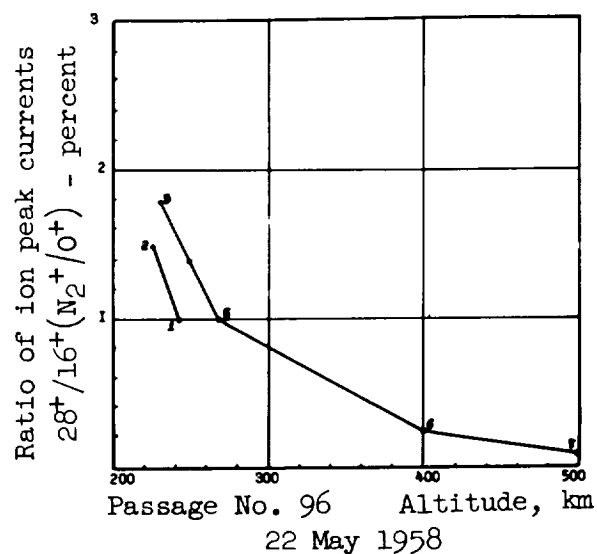

Figure 11.- The changing relative intensity of the ionic peak of molecular nitrogen according to altitude and geographic latitude (according to the data of one loop of May 22, 1958). The points are numbered in the same way as in figure 9.

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